INDENTED TUBE FOR A HEAT EXCHANGER

BACKGROUND OF THE INVENTION

The present invention relates to a method for forming a tube used in a heat exchanger including a plurality of indentations that increase heat transfer between a fluid flowing through the tube and a fluid flowing around the tube.

A shell and tube heat exchanger is used to cool fluids in various automotive applications, including exhaust gas recirculation coolers and power steering devices. In an engine gas recirculation system, an exhaust fluid flows inside the tube and exchanges heat with a coolant flowing around the tube. The exhaust fluid closer to the tube wall cools faster than the exhaust fluid flowing in the center of the tube.

In the prior art, the tubes in the heat exchanger can be bent or twisted to create turbulence in the exhaust fluid and to provide a non-linear flow path to increase heat transfer.

There are several drawbacks to the bent or twisted tubes of the prior art. For one, it is difficult to manufacture the tubes. Additionally, it is both costly and laborious to twist and bend the tubes to the desired shape.

Hence, there is a need in the art for a method for shaping a tube used in a heat exchanger that overcomes the drawbacks and shortcomings of the prior art.

SUMMARY OF THE INVENTION

A shell and tube heat exchanger includes a plurality of tubes surrounded by a shell. Each of the tubes includes a plurality of indentations. A cooling fluid flowing through the shell exchanges heat with a hot fluid flowing through the tubes. Preferably, the shell and tube heat exchanger is used in an exhaust gas recirculation system, and an exhaust fluid flows through the tubes and exchanges heat with a coolant flowing through the shell.

The tube includes indentations that increase the surface area of the tubes and the amount of fluid located proximate to the walls of the tubes. The indentations also create turbulence in the fluid flowing through the tubes.

In one example, a mold of a desired shape is placed in a desired position and orientation in a die. The tube is placed in a first position within the die, and the

mold crimps the tube to form the desired indentation in the tube. The mold is then released, and the tube is moved relative to the mold. The mold then again crimps the tube to form an additional indentation. The tube can be translated relative to the mold or can be both translated and rotated relative to the mold.

Alternately, the mold includes a roller that forms parallel grooves on the tube. The tube is translated relative to the mold to form the grooves on the surface of the tube. The number of rollers determines the number of grooves. Alternately, the tube is both translated and rotated relative to the mold to form a spiral groove on the surface of the tube.

These and other features of the present invention will be best understood from the following specification and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a cross-section of a shell and tube heat exchanger;

Figure 2 illustrates a die for molding a tube of the present invention in a first position;

Figure 3 illustrates the die for molding the tube in a second position;

Figure 4 illustrates a perspective view of a first embodiment of the tube including angled indentations;

Figure 5 illustrates a perspective view of the first embodiment of the tube including parallel indentations;

Figure 6 illustrates a perspective view of the embodiment of the tube including different angled indentations;

Figure 7 illustrates a cross-sectional view of a second embodiment of the tube including six grooves;

Figure 8 illustrates a cross-sectional view of the second embodiment of the tube including five grooves;

Figure 9 illustrates a cross-sectional view of the second embodiment of the tube including four grooves; and

Figure 10 illustrates a perspective view of a third embodiment of the indented tube including a spiral shaped groove.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Figure 1 illustrates a shell and tube heat exchanger 10 including a plurality of tubes 12 surrounded by a shell 16. Opposing end portions 26 of the tubes 12 are attached to a plate 14. The end portions 26 of the tubes 12 can be attached to the plate 14 by welding, press-fitting, or by any other means of attachment. A cooling fluid enters the heat exchanger 10 through an inlet 18 located at one end of the heat exchanger 10. The cooling fluid flows through the shell 16 and exchanges heat with a hot fluid that flows through the tubes 12. The fluid in the shell 16 exits the heat exchanger 10 through an outlet 19.

If the heat exchanger 10 is used with an exhaust gas recirculation system, an exhaust gas recirculation valve 21 controls the flow of hot fluid from an engine 13 or other component into the heat exchanger 10. If the heat exchanger 10 is used in an exhaust gas recirculation system, the hot fluid is an exhaust fluid. The hot exhaust fluid enters the tubes 12, and heat is transferred from the hot exhaust fluid to a coolant flowing in the shell 16 surrounding the tubes 12. The cooled exhaust fluid in the tubes 12 is then recirculated to the engine 13 or other component. Although an exhaust gas recirculation system has been illustrated and described, it is to be understood that other applications utilizing a tube and shell heat exchanger 10 may also use the tubes 12 of the present invention.

The tubes 12 include a plurality of indentations 30 that increase the surface area of the tubes 12, the amount of hot fluid that is proximate to the walls of the tubes 12 to increase the heat transfer, and the amount of turbulence in the fluid in the tubes 12. Creating turbulence in the hot fluid within the tubes 12 mixes the fluid in the center of the tube 12 and the fluid proximate to the walls of the tube 12. Thus, the fluid proximate to the walls of the tube 12 will continually change as the fluid circulates and flows through the tubes 12.

Figures 2 and 3 illustrate the method of forming the tube 12 of the present invention. A mold 22 of a desired shape is placed in a desired position and orientation in a die 20. The tube 12 is positioned in a first position 23 within the die 20. The mold 22 then crimps the tube 12 to form an impression or indentation 30 in the tube 12. The mold 22 is then released. A moving device 24 both rotates and translates the tube 12 relative to the mold 22. Once the tube 12 is in a second

position 25, as shown in Figure 3, the mold 22 again crimps the tube 12 to form an additional indentation 30 in the tube 12. The process of translating and rotating the tube 12 and using the mold 22 to crimp the tube 12 may be repeated as many times as needed to form the desired number and orientation of indentations 30 in the tube 12.

Figure 4 shows a first embodiment of the tube 12 of the present invention. The mold 22 crimps the tube 12 to form indentations 30 in the tube 12. The mold 22 is released from the mold 22, and the tube 12 is rotated and translated relative to the mold 22. The mold 22 then again crimps the tube 12 to form an indentation 30. In one example, the tube 12 is rotated approximately 5 and 10 degrees between successive crimps.

Alternately, shown in Figure 5, the tube 12 is only translated relative to the mold 22 and is not rotated when forming the indentations 30. The indentations 30 are substantially parallel to the flow path of the fluid flowing through the tube 12. Alternately, as shown in Figure 6, the mold 22 can form indentations 30 that are angled relative to the flowpath of fluid flowing through the tube 12. In both these examples, the mold 22 is released from the tube 12 between successive crimps.

The amount of rotation and translation of the tube 12 relative to the mold 22 may be varied to produce a pattern of indentations 30 that creates a desired amount of turbulence in the fluid flowing through the tube 12. For example, forming the indentations 30 at an angle relative to the flow path of the fluid through the tubes 12 can increase the amount of turbulence. One skilled in the art would know the desired orientation of the indentations 30 in the tube 12 to produce the desired turbulence.

The tubes 12 include the opposing end portions 26 that preferably have a substantially uniform circular cross-sectional shape. The cross-sectional shape of the end portions 26 may differ from the cross section of the tube 12. That is, the cross-section of the end portions 26 corresponds to the cross-section of the desired connector. This allows the tube 12 to be easily attached to various other tubes, hoses, or other desired connectors. The end portion 26 may also be formed as different pieces and later attached to each of the tubes 12.

Figures 7, 8 and 9 show an alternate embodiment of the tube 12 of the present invention. In these embodiments, the mold 22 includes a roller (not shown) installed within the die 20. The mold 22 is crimped on the tube 12, and the tube 12 is translated relative to the mold 22 without releasing the mold 22 from the tube 12. In this example, a continuous groove 34 is formed on the surface of the tube 12. The groove 34 increases the surface area of the tube 12, allowing more fluid to contact the walls of the tube 12 at a given time.

The mold 22 can include a plurality of rollers to form a plurality of substantially parallel grooves 34 on the tube 12. The rollers contact the tube 12 and are continuously crimped on the surface of the tube 12 to form parallel grooves 34 as the tube 12 translates relative to the rollers.

As shown in Figure 7, one example tube 12a includes six grooves 34a. Figure 8 shows another example tube 12b having five grooves 34b. Figure 9 shows another tube 12c having four parallel grooves 34c.

Figure 10 illustrates an alternate tube 12 including a substantially spiral shaped groove 38 formed on the wall of the tube 12. A roller contacts the wall of the tube 12 as the tube 12 is both rotated and translated relative to the mold 22 to form a substantially spiral shaped groove 38 on the tube 12. The roller is continuously crimped against the tube 12 while the tube 12 is both rotated and translated. The angle at which the roller is placed against tube 12 and the amount of translation and rotation of the tube 12 can be varied to produce the desired spiral shaped groove 38. Alternately, several rollers can be employed.

Although a preferred embodiment of this invention has been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of this invention. For that reason, the following claims should be studied to determine the true scope and content of this invention.